Incident Summary #II-1578772-2023 (#36933) (FINAL)

SUPPORTING INFORMATION	Incident Date		July 7, 2023
	Location		Delta
	Regulated industry sector		Gas - Natural gas system
	Impact	Injury – Qty injuries	0
		Injury – Injury description	N/A
		Injury – Injury rating	None
		Damage – Damage description	A boiler's field installed venting pipe and the venting outlet adapter (the boiler's vent system exhaust) integral to the boiler were damaged and separated from the boiler. A 90-degree venting fitting installed at the top of the boiler was blown off and landed in front of the boiler. The front cover of the boiler was blown open, and the boiler enclosure insulation material was separated from the inside of the cover. The boiler pressure relief valve drain piping was broken.
		Damage – Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		While doing a walk-through check of the mechanical room at a multi-residential building, the caretaker observed damage to boiler # 3 which was one of four boilers at the site. Evidence showed a high-pressure event had occurred causing damage to the equipment. The cover of the boiler was blown open, the insulation was separated from the boiler cover, and ignition error messages were displayed on the boiler digital control display. The boiler venting was observed to be separated from the adapter at the top of the boiler. There was damage to the field installed vent piping that included a short piece of venting that was cracked and a 90-degree fitting that was blown from the venting system as well as damage to the internal vent pipe and venting tube adapter at the top of the boiler. The boiler was not running when it was discovered but power and gas were immediately turned off by the caretaker to prevent the boiler from running.
INVESTIGATION	Site, system and components		**The water heating boiler system:** The 90 unit, six story, multi residential building had the domestic hot water and heating boiler system installed in 2018 at the time the building was being newly constructed. The domestic hot water heating system consists of four Triangle Tube Prestige 399 BTU natural gas boilers that operate in tandem depending on the heating demand to heat and circulate water throughout the building for domestic use. Storage tanks, piping, and pumps are used to store and circulate the hot water that is heated by the boilers throughout the building. The system was set up to have boiler #4 as the primary boiler and boiler 1, 2, and #3 as secondary boilers that are configured to operate together to keep

the water at the set point temperature depending on the demand for hot water.

Venting system:

Under normal operation, the products of combustion from a natural gas burning boiler are exhausted to the exterior of the building through the field installed venting system. This is designed to prevent products of combustion including Carbon Monoxide (CO) from entering indoor spaces.

The venting system for each boiler is comprised of 4-inch diameter polypropylene venting pipe for both the exhaust and the combustion air. Sections of venting pipe are fitted together and secured using retention clips specifically designed and approved for the venting system. The venting system is required to be properly supported with the use of hangers and clamps designed to hold the venting in place to reduce strain at connections and terminations.

The venting system was attached to the top of the boiler at the time of installation by inserting the vent pipe into the boiler venting outlet adapter and tightening the adapter securing screw and clamp. The venting adapter is intended to hold the field installed venting securely to the boiler venting system.

The polypropylene venting length is specified by the boiler manufacture and is not permitted to exceed a total length of 100 feet according to the manufacture's installation instructions. Any 90-degree bends installed throughout the venting run are calculated as the equivalent to adding 10' to the venting length. The venting for this boiler was determined to have an approximate equivalent length of 80' – 90'.

In July 2020, Health Canada issued a consumer product recall notice related to the adapter located at the top of the boilers. The following is an excerpt from the recall.

"Issue: Flue gas can escape from the gas boilers if the vent adapter is not securely reattached to the boiler after maintenance or repair, posing a carbon monoxide poisoning hazard."

https://recalls-rappels.canada.ca/en/alert-recall/triangle-tube-s-prestige-solo-prestige-excellence-condensing-gas-boilers-recalled

A recall was also issued by the US Consumer Product Safety Commission in July of 2020 related to the adapter located at the top of the boilers. The following is an excerpt from the recall.

"…Risk of Carbon Monoxide Hazard; one death reported…"

https://www.cpsc.gov/Recalls/2020/Triangle-Tube-Recalls-to-Repair-Gas-Boilers-Due-to-Risk-of-Carbon-Monoxide-Hazard-One-Death-Reported-In-Home-Remedy-May-Be-Delayed-Due-To-COVID-19-Restrictions

It was stated in the recall that the hazard was the vent adapter, which attaches the vent exhaust tube to the boiler, can allow flue gas to escape if not correctly reattached to the boiler after maintenance or repair. This would pose a carbon monoxide poisoning hazard to consumers.

The recall effected approximately 63,000 boilers in the US and 6,600 in Canada.

The suggested remedy was a free repair with contact information for coordination with the manufacturer to have the repair completed by a qualified contractor.

Consumers were advised that if they were to continue to use the boiler prior to the repair they should ensure they have a working CO alarm outside of sleeping rooms and on each level of their home and offered to supply one and ship it for free if consumers did not already have one installed.

The original manufacturer installed adapter was affixed to the top of the boiler using a twist on locking mechanism during the manufacturing process. The provisions of the recall require the existing twist on adapter to be affixed to the top of the boiler with 4 mechanical fixing screws required to be used to affix the adapter to the boiler with the purpose of preventing separation of the venting system.

Excerpt from 2020 recall letter from Triangle tube:
“Triangle Tube is conducting a voluntary product recall to repair certain boilers in cooperation with the U.S. Consumer Product Safety Commission (CPSC) & Health Canada. After repair or maintenance, flue gas can escape from the boiler if the vent adapter is not securely reattached to the boiler. This would pose a carbon monoxide poisoning hazard to customers. We have changed the way our vent adapters attach to the top of the boilers and want to see that change applied to all boilers. This recall will help ensure that the vent adapters continue to provide a gas-tight seal.”

https://cdn.triangletube.com/getmedia/244288b0-aeb9-4207-a3d0-ddd40f40f845/2020-70-Recall-Letter-to-Consumer_1.pdf

Delayed ignition:

Delayed ignition and “Hard light off” occurs when an excessive amount of gas is present in the combustion chamber when the boiler ignites. Under certain circumstances this can result in a detonation that may cause the internal venting parts of the boiler as well as the field installed external venting parts to separate, become damaged, or detached from the boiler.
Depending on the pressure of the detonation and the integrity of the venting installation, the venting can separate and detach with a great amount of force which can pose a safety hazard to individuals that may be in proximity of the equipment during detonation.

Damaged or separated venting within the boiler or to the external venting system can also cause the venting system to remain disconnected or dislodged and open which poses a potential hazard of CO entering occupied

spaces if the boiler continues to run.

Delayed ignitions can happen for multiple reasons related to the equipment's manufacture, installation, operation, and maintenance. Delayed ignition is expected throughout the service life of a boiler however delayed detonations causing a high-pressure event should not create an unsafe condition by damaging internal flue gas venting components or external venting systems

Ignition system:
The boiler has an ignition system that is designed to go through an ignition cycle that prior to ignition purges any fuel in the combustion chamber with a specified amount of air changes. Gas is then injected into the combustion chamber through the burner and then the electronic ignitor operates to ignite the gas at the burner. Once the gas at the burner is ignited the system confirms the boiler is lit and the boiler is then allowed to operate and begins to heat the water. The ignition cycle must meet the requirements of the approval standard for boilers ANSI Z21.13-CSA4.9.

The boiler employs an ignition sequence that is intended to clear any unburnt gas from the boiler if a burner flame is not sensed during the ignition attempt. The boiler's fan operates after a failed ignition attempt to remove any remaining combustible gases from the combustion chamber and venting system to allow for a proper combustion sequence on the subsequent ignition attempt.

The operational and testing requirements for this type of boiler including the multi-try ignition sequence are defined in the ANSI Z21.13-CSA4.9 approval standard.

The boiler ignitor:
The boiler ignitor has two legs (probes) and is designed to operate with a gap of 3mm (distance between the two probes) to ensure the ignitor is producing a reliable and consistent spark for ignition.
The ignitor gap is a critical factor in ensuring proper boiler ignition. If the gap is increased or decreased, it can negatively affect the ignition. Characteristics of the ignitor system are as follows:

- High-energy on-board spark.
- Spark voltage: 18 KV.
- Spark frequency: 21 Hz.
- Spark pulse energy: 12 µAs.
- Spark to Earth.
- Ignitor gap 3mm.
- Gap from ignitor to basket 28mm.

Ignitor system maintenance:
Ignitor maintenance involves removing and cleaning the ignitor probes, testing the electronic ignitor circuit wiring, and grounding connections, and ensuring that the ignitor probe gap, and ignitor gap to the burner is as specified by the manufacturer.

If the ignitor is not observed to be in proper operating condition during maintenance and the gaps are out of specification, the boiler can fail to ignite during the ignition cycle. If the boiler does fail to ignite it typically goes through the ignition cycle again for up to five tries until a lockout. The boiler has a digital display on the front cover that displays operating parameters of the boiler as well as any error codes and allows the operator to interact with the boiler to change settings to tailor the operation of the boiler.

In 2020 an “engineering bulletin” was issued by the boiler manufacturer for a replacement ignition system. The bulletin included the ignitor rod assembly as well as the electronic ignition components that generate the spark current. The manufacturer’s engineering bulletin indicates the change was due to a supply chain assessment that was made to ensure continuity of supply for replacement parts throughout the boilers expected lifetime.

https://cdn.triangletube.com/wp-content/uploads/2021/11/10145035/EB051-Prestige-PA-Series-Obsolete-Components-050820.pdf

Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless, tasteless gas that is toxic to humans and animals (Image 20).

Exposure to carbon monoxide interferes with the body’s ability to absorb oxygen, which can result in serious illness or death.

Symptoms of carbon monoxide poisoning can present similar to flu symptoms: headaches, nausea, dizziness, or vomiting.

Fuel burning appliances such as a boiler operating with detached or dislocated vents are a CO hazard, combined with installation, setup, and lifecycle maintenance challenges the hazard can become a much higher risk with an increase in CO concentration in the flue gas.

For more information on carbon monoxide, visit Carbon Monoxide Safety Tips at https://www.technicalsafetybc.ca/public-safety/carbon-monoxide- safety.

Incident Summary #II-1578772-2023 (#36933) (FINAL)

Failure scenario(s)	The boiler was installed by a licensed gas contractor in 2018 during construction of the building. In July 2020 Health Canada and the US Consumer Product Safety Commission issued consumer product recalls that resulted in the manufacturer requiring 4 mechanical fixing screws to be installed to secure the venting output adapter to the top of the boiler. The boiler involved in the incident only had three screws installed. Information regarding the requirements for CO alarms to be installed above the boilers was also part of this recall and it was recommended that if continuing to operate the boiler, the CO alarms should be installed. In June of 2023 a licensed contractor performed maintenance on the boiler that included a “strip and clean”. This involved removal and cleaning of the burner and heat exchanger with a vinegar solution. The boiler was deemed by the contractor as suitable for operation at the time of the servicing. The ignitor was not changed during the service visit.
	During a routine check on July 7, 2023, the building caretaker entered the boiler room and noticed that the cover on boiler #3 was blown open and the cover insulation was detached from the cover. The boiler had experienced a detonation during a delayed ignition event that damaged the boiler’s internal venting components as well as the field installed venting that was connected to the boiler. Five “ignition fail” events on the “Lockout History” and an “Ignition Failed” screens were displayed on the digital display on the cover of the boiler and the venting was detached and damaged at the vent outlet adapter at the top of the boiler. After further observations, the internal venting was also observed to be detached and damaged inside the boiler. The boiler was not in operation at the time the incident was discovered. The caretaker turned the boiler’s power switch off and closed the gas supply valve to the boiler. Disassembly and investigation of the boiler after the incident revealed that the ignitor gap was 4.47mm which is greater than the manufacture’s specified ignitor gap of 3mm. The boiler does not incorporate any safety mechanisms to prevent it from running or being restarted if the venting system is detached from the top of the boiler or if the venting system becomes dislodged or detached anywhere else throughout the venting system’s length.

Incident Summary #II-1578772-2023 (#36933) (FINAL)

Facts and evidence	**Interview and observations of the caretaker following their routine boiler room check on the day the incident was discovered and reported:** • The boiler cover was blown open and the internal insulation was detached and hanging from the boiler cover (Image 1). • Five "ignition fail" events on the "Lockout History" and "Ignition Failed" screens were displayed on the digital display on the cover of the boiler (Image 12 and Image 13). • The venting was detached from the top of the boiler at the vent outlet adapter (Image 6). • The field installed venting pipe was damaged and cracked from the force of the detonation (Image 5 and Image 6). • The 90-degree bend on the venting pipe at the top of the boiler was blown off the venting adapter and venting pipe. (Image 1 and Image 6). • The polypropylene venting pipe on the inside of the boiler was dislodged from the polypropylene pan at the base of the boiler where the venting pipe and the heat exchanger are interconnected. The venting seal was also dislodged (Image 5 to Image 10). • The pressure relief valve drainpipe was broken near the relief valve (Image 11). **Technical Safety BC Gas Safety Officer observations during site investigation:** • Witnessed ignitor gap measurements performed by the manufacturer of the boiler (Image 15). • The venting output adapter for Boiler # 3 only had 3 screws as opposed to the 4 screws required by the boiler recall. • Carbon Monoxide detectors were not found in the mechanical room as recommended by the Health Canada recall. • Witnessed the original ignitor system still installed on the boilers. All four boilers did not have the ignitor rod assembly as well as the electronic ignition components recommended to be replaced by the manufacture under their issued engineered bulletin. • Witnessed the installation of the new ignitor rod assembly as well as the electronic ignition components recommended by the issued manufacture engineering bulletin. • Witnessed measurements of the newly installed ignitor gap distance between rods and distance from basket to rod. Witnessed the significant change of design between the old and new ignitor system. The new ignitor system is an approved replacement part within their certification standard.

Incident Summary #II-1578772-2023 (#36933) (FINAL)

Triangle Tube representatives onsite testing and site observations:

- Measurement of boiler #3 ignitor leg (prong) gap after the incident showed the gap to be 4.47m. The manufacturer's specified gap for the ignitor is 3mm (Image 14, Image 15, and Image 16).
- Measurement of the boiler #1 existing ignitor gap was taken as a comparison and showed the gap to be 3.16mm (Image 17).
- Measurement of the gap between the ignitor legs and the burner for boiler #3 was 27.61mm which is close to the manufacturer's specification of 28mm (Image 18).
- The manufacturer's replacement ignitor outlined in the manufacture's technical bulletin specifies a much closer distance of 7.2mm between the ignitor legs (prongs) and the burner for the replacement ignitor installation (Image 19).

Interview with the Licensed contractor's gas fitter that services this site:

- A full strip and clean of the boiler was performed in June of 2023.
- The combustion chamber and heat exchanger where disassembled and cleaned with a vinegar solution.
- The original ignitor had not been replaced. It was re-installed at the time of servicing.
- The ignitor did not appear to be damaged or worn out at time of service.
- The ignitor gap was not checked at the time of servicing.
- The boiler was put back into operation after the strip and clean servicing.
- The adapter recall and installation of all four "fixing screws" had not been performed.
- The gas fitter indicated that he had not installed any of the three output adapter screws that were observed to have been installed.
- After the incident the gas pressures were within tolerable parameters during boiler run and high fire test performed with Triangle Tube representatives on site.

Interview with Triangle Tube North American representative and correspondence:

- The boiler can run with the venting disconnected from the vent output adapter.
- Delayed ignitions are expected throughout the service life of an appliance and cannot be avoided. Polypropylene venting is the preferred venting system for this type of boiler.
- The boiler does not incorporate any safety mechanisms to prevent the boiler from running or being restarted if the venting system is detached from the top of the boiler or if the venting system becomes dislodged or detached anywhere else throughout the venting system's length.

- From the manufacturer's correspondence with Technical Safety BC, it was stated that the Mechanical fixings are more forgiving for the range of errors that can be introduced during installation and maintenance.

Boiler certification standards:

- Boiler standard ANSI Z21.13 CSA 4.9.
- Polypropylene venting standards ULC-S636.
- Boilers and venting systems are tested independently during the certification and approval process.

Health Canada Recall:

- **"Triangle Tube's Prestige Solo & Prestige Excellence Condensing Gas Boilers Recalled to Repair Due to Risk of Carbon Monoxide Poisoning Hazard."**
- https://recalls-rappels.canada.ca/en/alert-recall/triangle-tube-s-prestige-solo- prestige-excellence-condensing-gas-boilers-recalled.

US Consumer Product Safety Commission Recall:

- **"Triangle Tube Recalls to Repair Gas Boilers Due to Risk of Carbon Monoxide Hazard; One Death Reported; In-Home Remedy May Be Delayed Due To COVID-19 Restrictions Fast Track Recall with Health Canada."**
- https://www.cpsc.gov/Recalls/2020/Triangle-Tube-Recalls-to-Repair-Gas- Boilers-Due-to-Risk-of-Carbon-Monoxide-Hazard-One-Death-Reported-In- Home-Remedy-May-Be-Delayed-Due-To-COVID-19-Restrictions

Triangle Tube Safety Recall:

- https://cdn.triangletube.com/getmedia/244288b0-aeb9-4207-a3d0- ddd40f40f845/2020-70-Recall-Letter-to-Consumer_1.pdf

Triangle Tube Technical Bulletin:

- **"PRESTIGE PA Series Obsolete Components"**
- https://cdn.triangletube.com/wp-content/uploads/2021/11/10145035/EB051- Prestige-PA-Series-Obsolete-Components-050820.pdf

Triangle Tube Vent Outlet Adapter Kit:

- https://cdn.triangletube.com/wp-content/uploads/2021/08/13140206/2011-66- Prestige-PP-Vent-Outlet-Adapter-Kit-for-PS-399-and-PT-399-Boilers.pdf

Incident Summary #II-1578772-2023 (#36933) (FINAL)

Causes and contributing factors	It is very likely that delayed ignition caused detonation of natural gas within the boiler combustion chamber that resulted in internal damage to the boiler venting and damage/disconnection of the field installed venting system. It is possible that the ignitor gap of 4.47mm instead of the manufacture's specified 3mm gap contributed to the delayed ignition by not providing an adequate spark for ignition. Delayed ignition can occur for a variety of reasons and the boiler venting system was unable to withstand the detonation forces from an expected delayed ignition occurrence. Boilers with damaged, dislodged, or detached venting systems that have no safeties in place to prevent them from operating under these conditions can create a significant hazard by allowing CO to enter occupied spaces.

Image 1 - This image was provided by the caretaker and shows what he observed when entering the boiler room during his routine check of the boiler equipment on the day he reported the incident. The orange outline shows boiler #3 that experienced a detonation during a delayed ignition event. The cover was blown open from the force of the incident and the insulation was separated from the interior of the boiler enclosure. The red outline shows the 90-degree polypropylene fitting that was blown off the venting pipe that was terminated on the venting output adapter at the top of the boiler.

Image 2 - All four boilers that form part of the water heating system. The output venting comes off the top of the boilers with a short piece of polypropylene vent pipe and then transitions to 90-degree bends so the piping can be routed to the location where it enters another 90-degree bend and rises through the building structure to the roof.

Image 3 - This image was provided by the caretaker and shows the venting output adapter dislodged from the boiler enclosure.

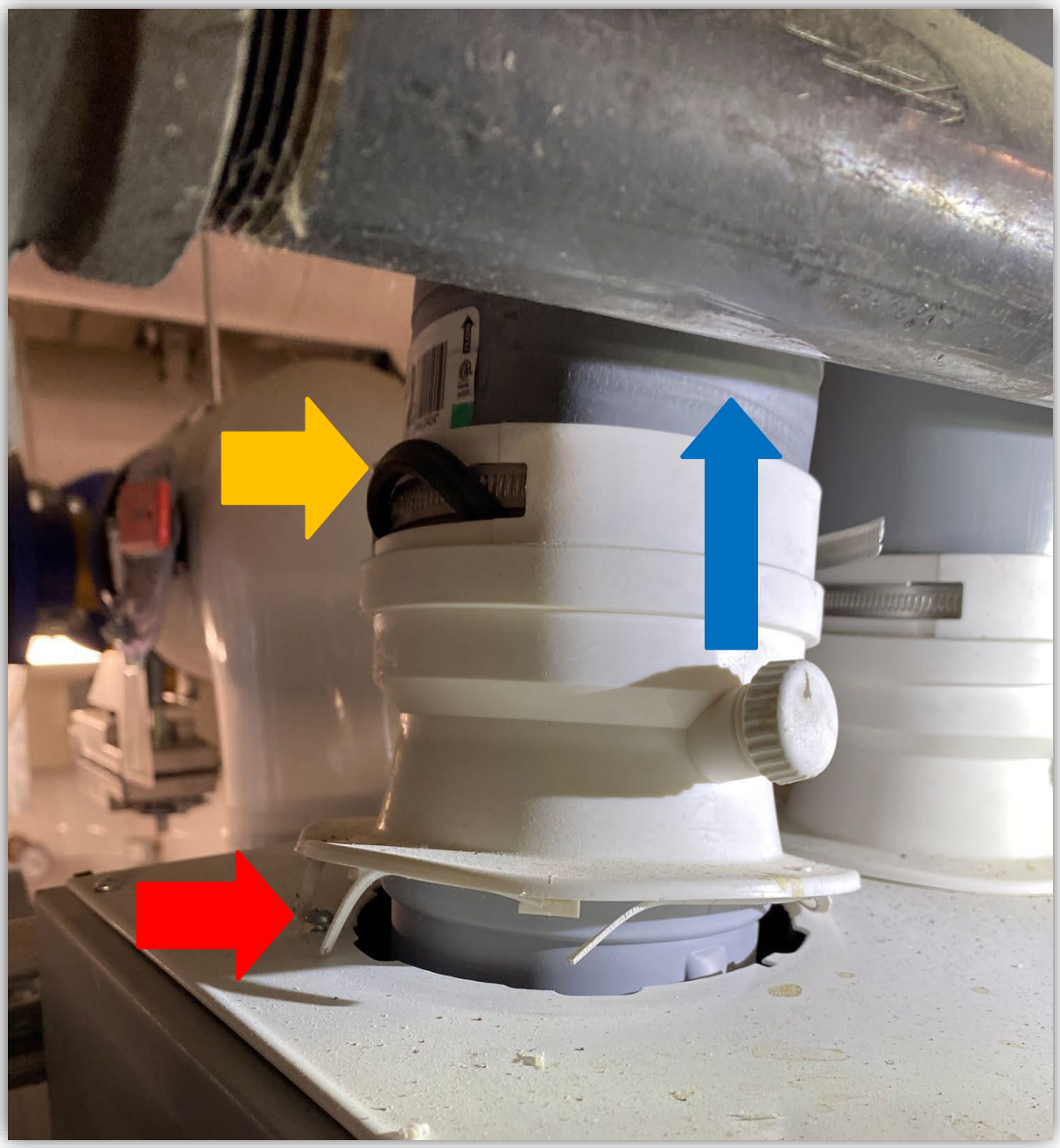


Image 4 - Another angle of the dislodged venting output adapter. The red arrow shows where the adapter has been pulled away from one of the screws (screw #1) that is intended to hold it in place. The orange arrow shows the vent outlet adapter seal dislodged. The blue arrow shows marks on the vent piping where the securing clamp was holding the pipe prior to the pipe being dislodged by the force of the detonation.

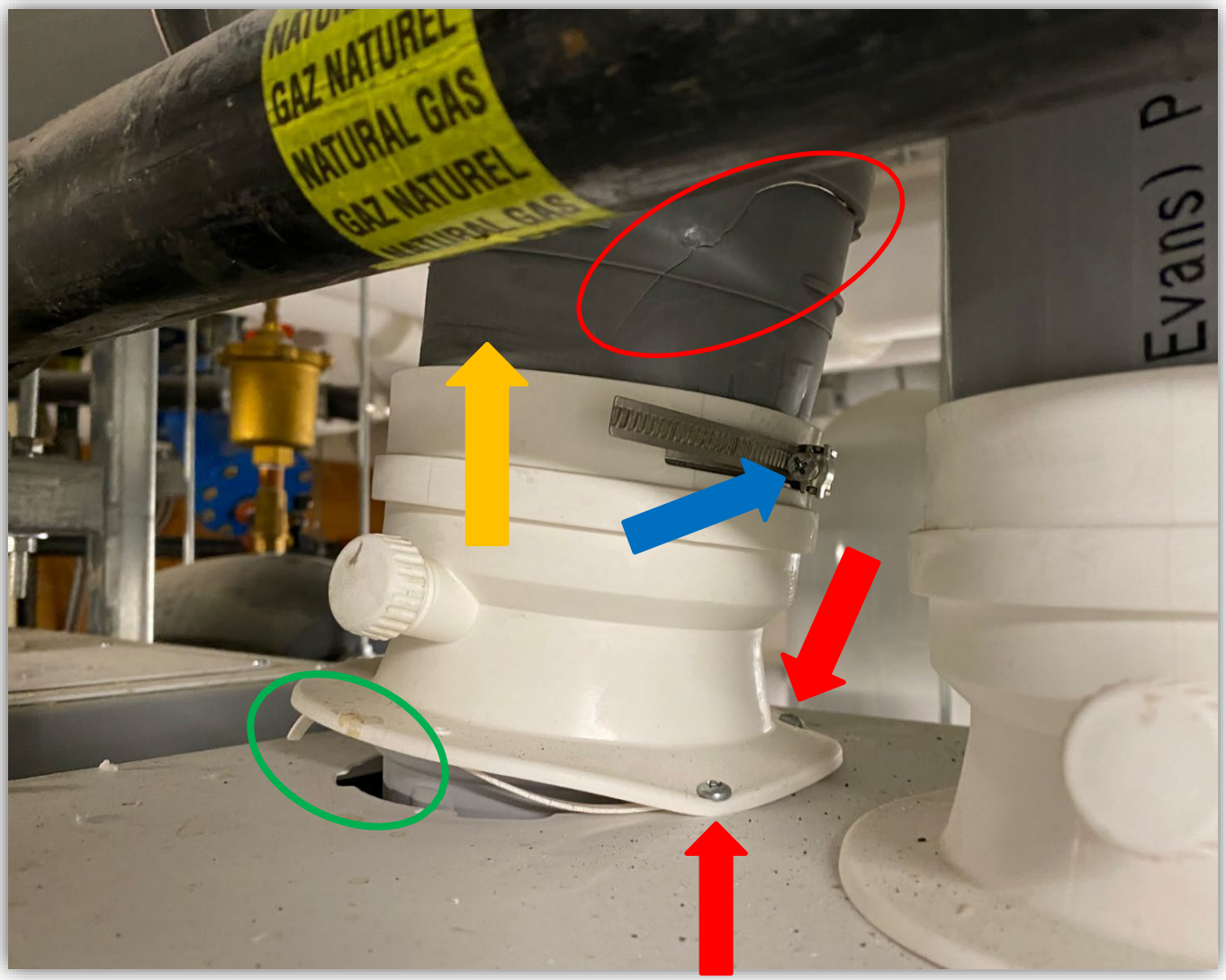


Image 5 - The venting outlet adapter pulled away from the boiler enclosure. The red arrows show screw #2 and screw #3. The red outline shows the venting pipe cracked above the adapter. The blue arrow shows the vent outlet adapter tightening screw used to secure the venting in place once installed. The orange arrow shows marks around the pipe where the vent adapter securing clamp was tightened on to the pipe prior to the detonation. The green outline shows the area where the fourth screw should have been installed as per the manufacturer's recall for the venting output adapter.

Image 6 - This image was provided by the caretaker and shows the 90-degree polypropylene venting fitting missing from the venting system at the top of the boiler. The fitting was blown off the venting system from the force of the detonation caused by the delayed ignition event. The red outline shows the venting pipe cracked from the force of the detonation.

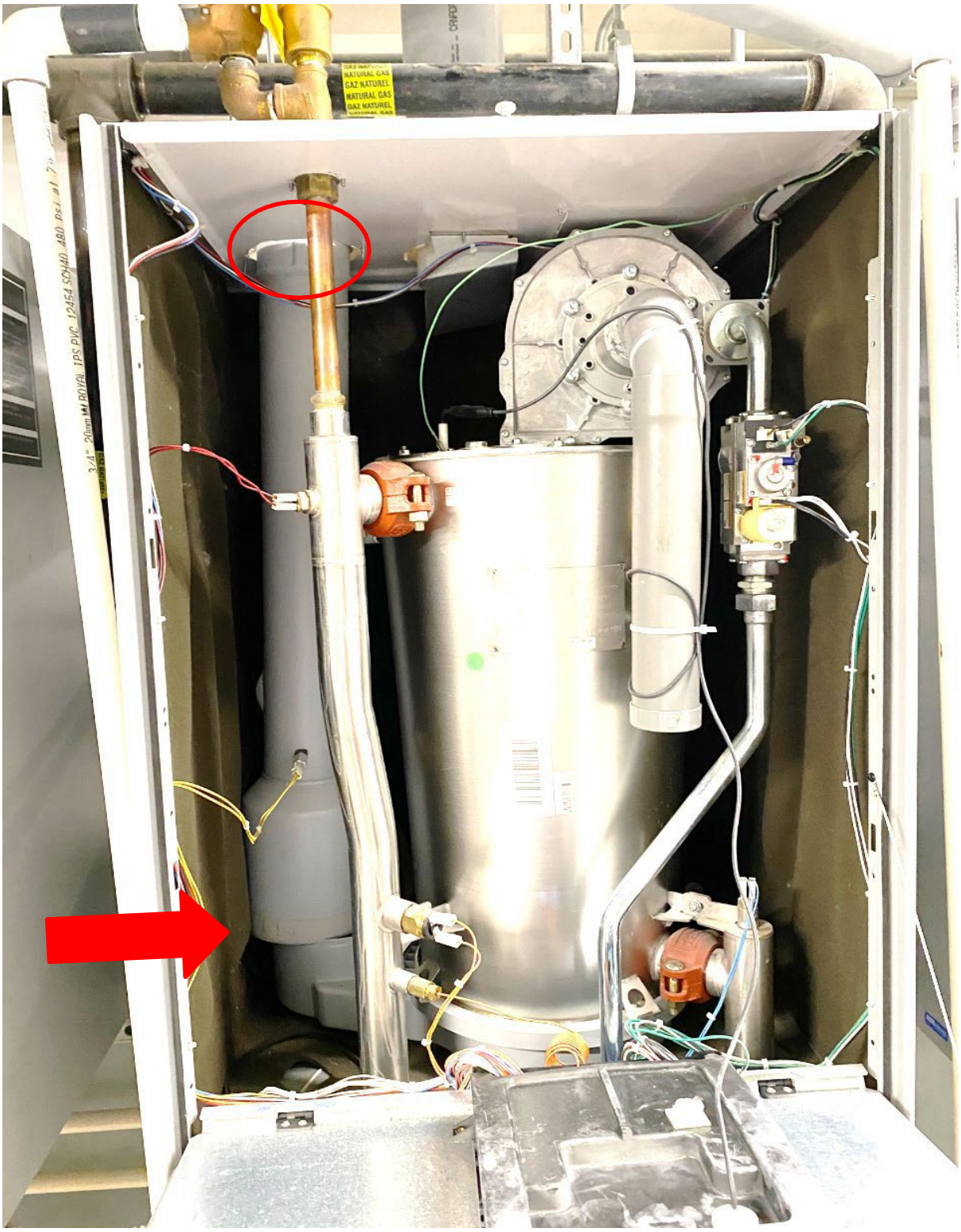


Image 7 – The interior of the boiler #3 enclosure after the incident. The red outline shows where the internal venting piping connects to the boilers venting output adapter at the top of the boiler. Light coming from outside of the boiler at the top is visible where the adapter was pulled away from the boiler enclosure and the red arrow shows where the internal venting pipe was dislodged from the condensate pan at the bottom of the boiler. Both conditions were caused by the detonation during the delayed ignition event.

Image 8 - This image was provided by the caretaker. The orange outline shows the internal venting output pipe dislodged from the condensate pan. The condensate pan fitting gasket is intended to make a seal around the venting pipe. The photo also shows the gasket dislodged.

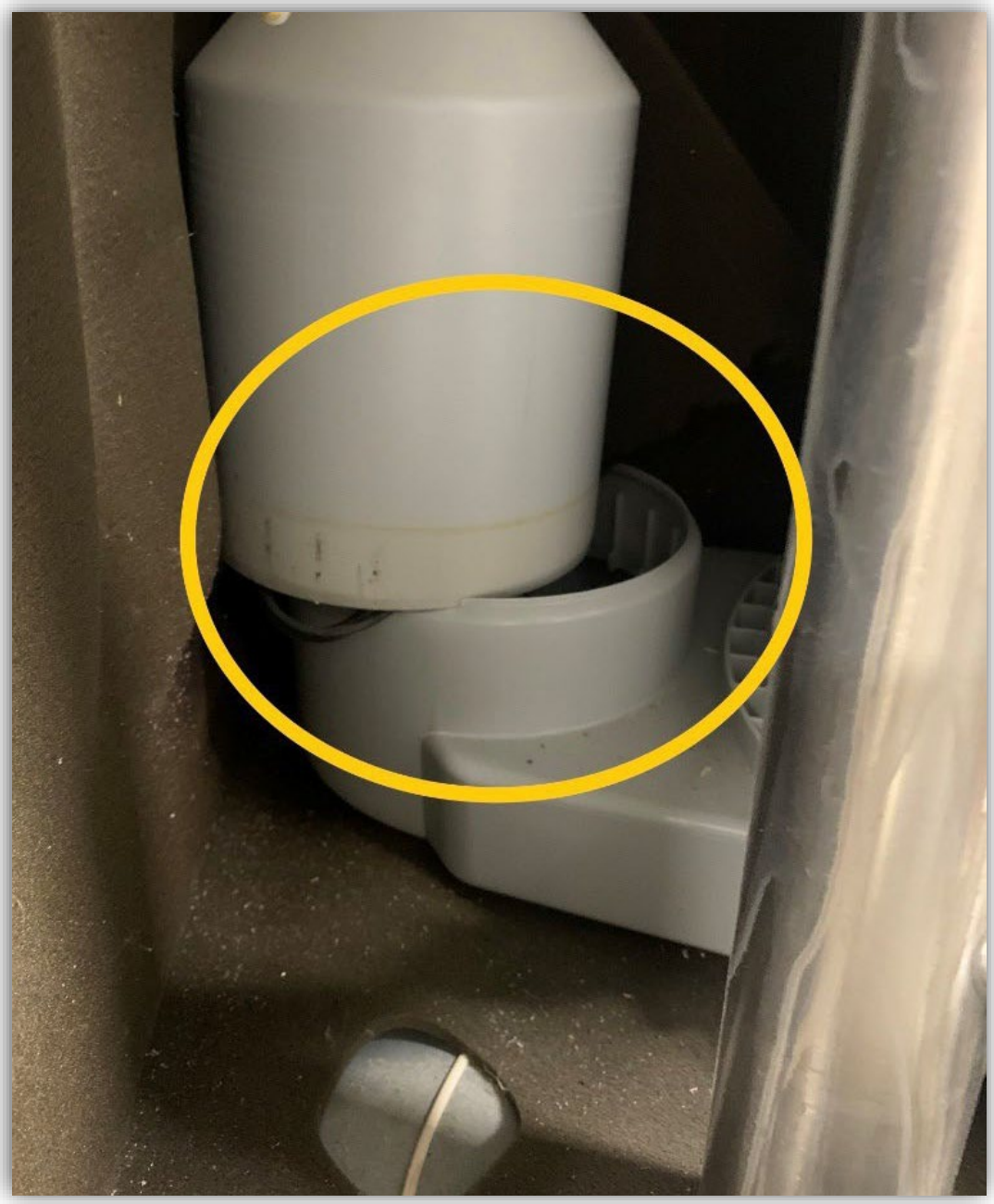


Image 9 - This image was provided by the caretaker. The orange outline shows the internal venting output pipe dislodged from the condensate pan. The condensate pan fitting gasket is intended to seal around the venting pipe. The photo also shows the gasket dislodged.

Image 10 - The internal venting pipe dislodged inside the boiler enclosure. The red arrow shows the gasket intended to seal the connection between the venting pipe and the fitting.

Image 11 - This image was provided by the caretaker and shows the pressure relief draining piping broken and dislodged after the incident.

Image 12 - The display on the front of Boiler #3 involved with the incident. At the time of the incident the lockout history displayed five failed ignition errors.

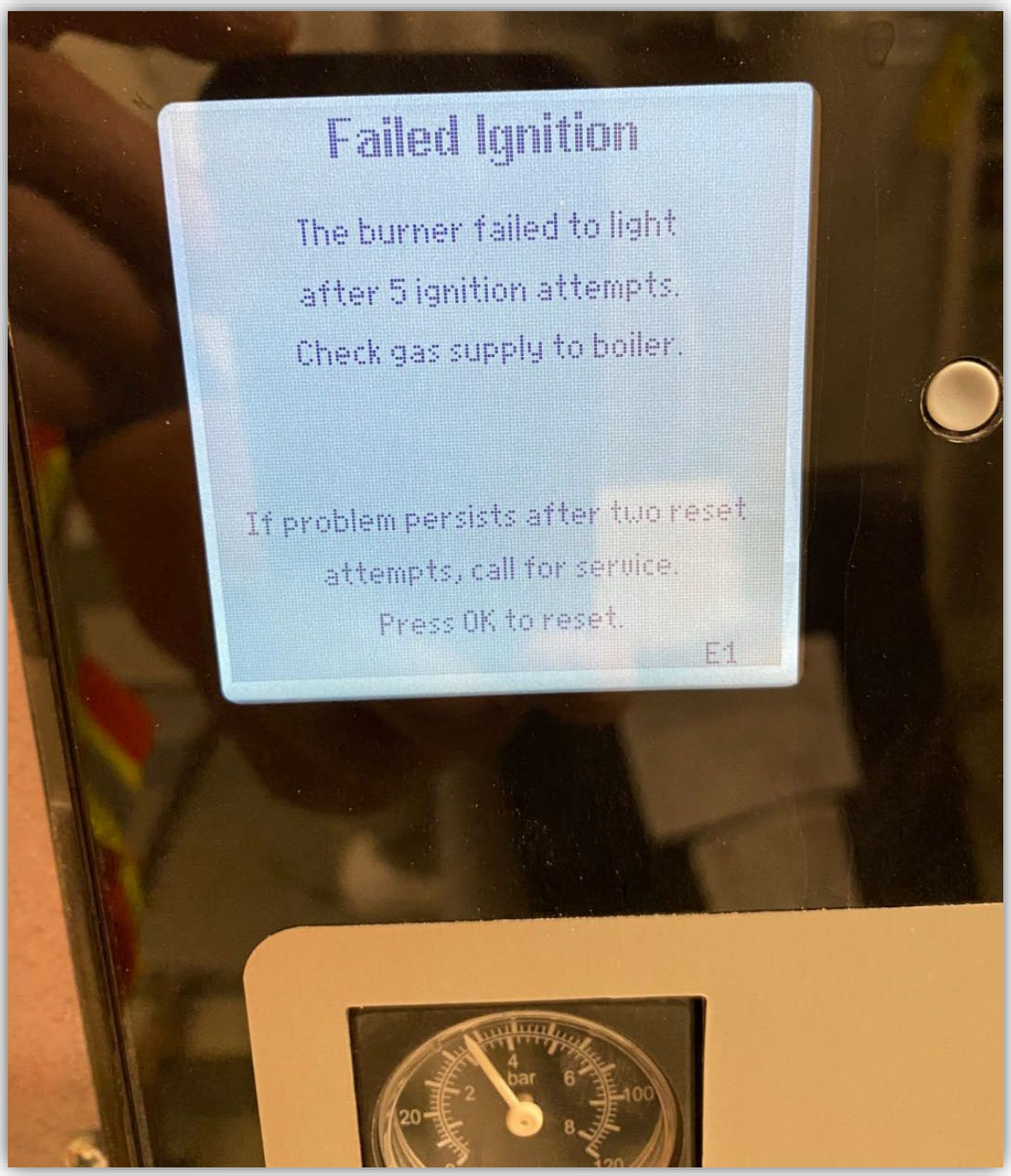


Image 13 – A failed ignition warning and instructions to call for service.

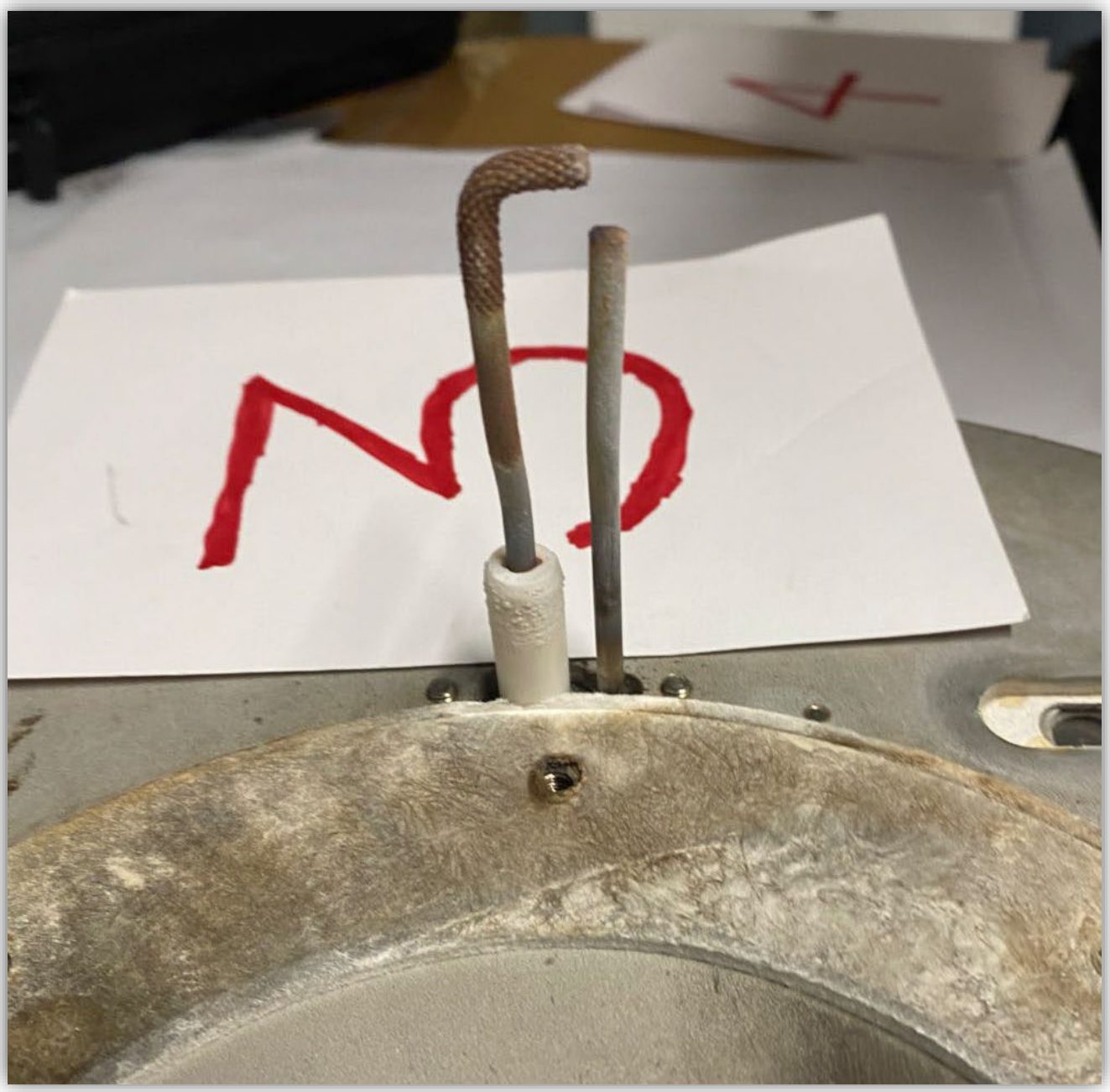


Image 14 - The ignitor from boiler #3 that was involved in the incident.

Image 15 - The gap measurement between the ignitor probes for ignitor #3, as measured by the boiler manufacturer representative. The measurement shows 4.47mm which is greater than the manufacturer's specification for the gap which is 3mm.

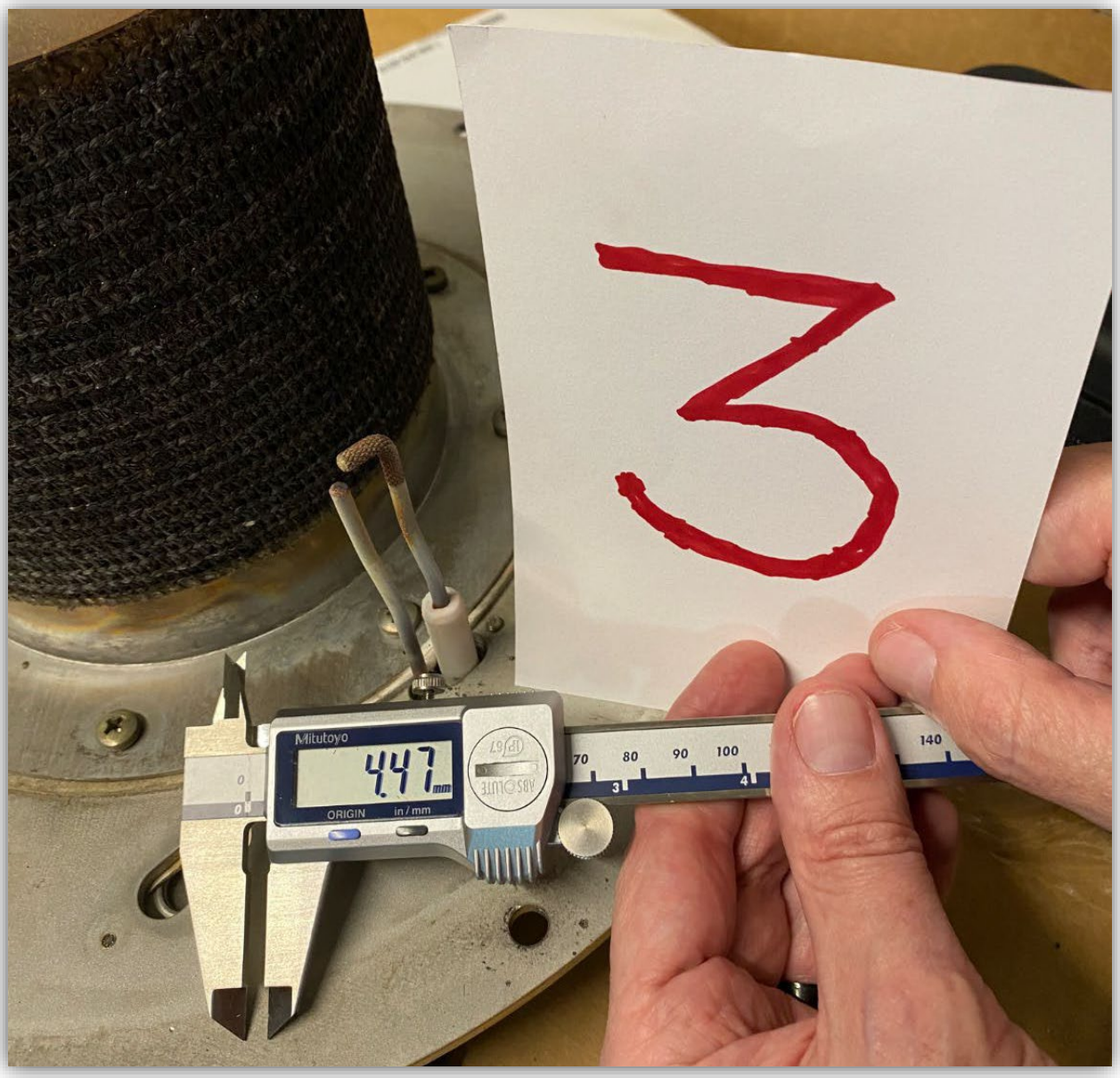


Image 16 – The gap measurement between the ignitor probes for ignitor #3. The measurement shows 4.47mm which is greater than the manufacturer's specification for the ignitor gap which is 3mm.

Image 17 - The ignitor gap from boiler #1 was 3.16mm, which is much closer to the manufacturer's specification of 3mm than the ignitor from boiler #3 at 4.47mm.

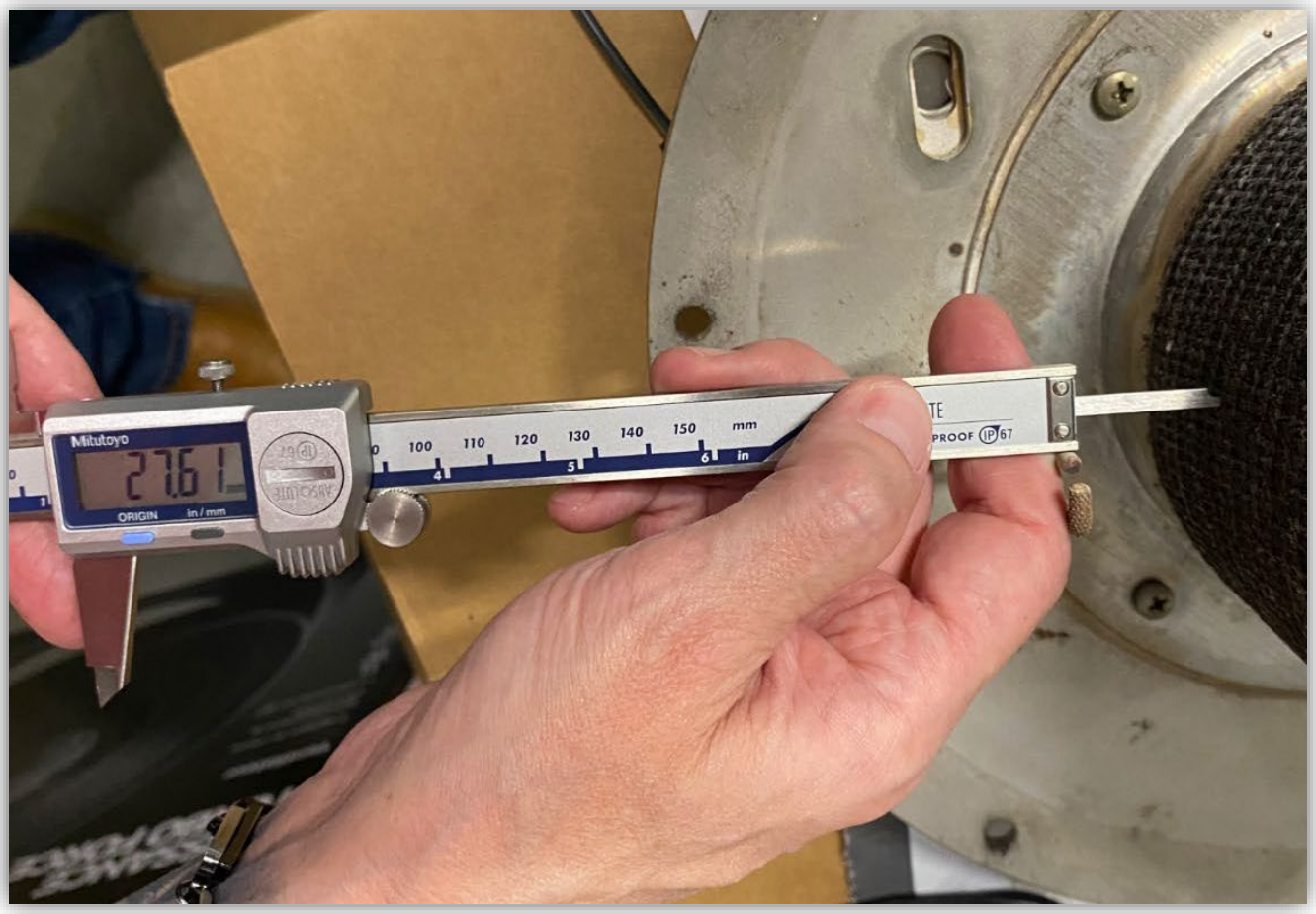
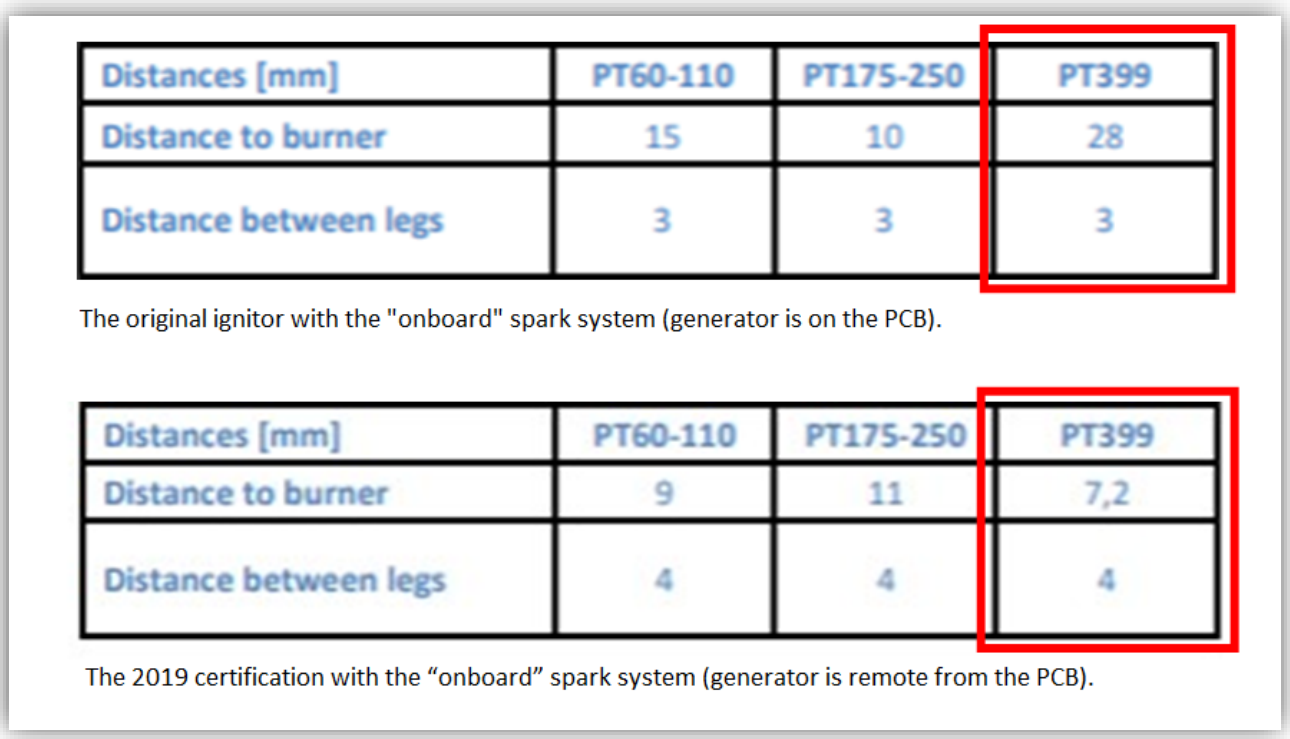


Image 18 - This image shows the distance from the ignitor to the boiler burner for boiler #3. The distance was 27.61mm which is close to the manufacturer's specification of 28mm. The manufacture's replacement ignitor outlined in the manufacture's technical bulletin specifies a much closer distance of 7.2mm between the ignitor legs (prongs) and the burner (Image 19).



Distances [mm]	PT60-110	PT175-250	PT399
Distance to burner	15	10	28
Distance between legs	3	3	3

The original ignitor with the "onboard" spark system (generator is on the PCB).

Distances [mm]	PT60-110	PT175-250	PT399
Distance to burner	9	11	7,2
Distance between legs	4	4	4

The 2019 certification with the “onboard” spark system (generator is remote from the PCB).

Image 19 - The manufacture’s specified distances between the ignitor and the burner and the distance between the ignitor legs for the original ignitor (top) and the replacement ignitor (bottom). The ignitor leg gap is very similar going from 3mm to 4mm however the distance from the ignitor to the burner gap is significantly less going from 28mm to 7.2mm for the replacement burner.

Properties of Carbon Monoxide

Colourless	Cannot be seen.
Tasteless	Cannot be detected through the sense of taste.
Odourless	Cannot be detected by sense of smell, However, CO can also be accompanied by aldehydes. Aldehydes' odour can somewhat resemble vinegar, which can be detected by the sense of smell, and may also result in a metallic taste in the mouth.
Non-irritating	Carbon Monoxide will not cause irritation. However, aldehydes usually present with higher levels of CO will irritate the eyes, nose, and mucous membranes.
Specific gravity	Slightly lighter than air (Sg 0.975). It may, but not always collect near the ceiling, and mixes freely with air.
Flammable (explosive) limits	CO is flammable between concentrations of 12.5% to 74% when mixed with air. Its ignition temperature is 609ºC (1128ºF).
Toxic	Can cause death if enough is absorbed into the bloodstream.

Chart 1 - Properties of Carbon Monoxide – From Technical Safety BC's "Carbon Monoxide Handbook"

Concentrations (*ppm)	Observations and Health Effects
1 to 3	Normal.
25	Occupational exposure limit averaged over 8 hour period.
30 to 60	Exercise tolerance reduced.
100	15-minute short-term exposure limit (STEL).
60 to 150	Frontal headache. Shortness of breath on exertion.
150 to 300	Throbbing headache, dizziness, nausea, and impaired manual dexterity.
300 to 650	Severe headache; nausea and vomiting; confusion and collapse.
700 to 1000	Coma and convulsions.
1200	Immediately dangerous to life and health (IDLH).
1000 to 2000	Heart and lungs depressed. Fatal if not treated.
Above 2000	Rapidly fatal.

*1 ppm = 1 part of gas per million parts air by volume

Chart 2 - Carbon Monoxide concentrations and health effects – From Technical Safety BC's "Carbon Monoxide Handbook"

Image 20 – Properties of Carbon monoxide chart.